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Claims

[c1] A method of making an interconnect structure comprising the steps of:
depositing a titanium layer on an interconnect structure having one or more contact openings which expose one or more silicide regions;
subjecting said deposited titanium layer to an in-situ plasma nitridization process;
depositing at least one layer of titanium nitride on said in-situ plasma-treated titanium layer; and
filling said contact openings with tungsten.

[c2] The method of claim 1 wherein the silicide of said silicide regions is comprised of silicon and a metal selected from the group consisting of cobalt, nickel, titanium, tungsten, platinum and molybdenum.

[c3] The method of claim 2 wherein said silicide is comprised of a nickel silicide.

[c4] The method of claim 2 wherein said silicide is comprised of a cobalt silicide.

[c5] The method of claim 2 wherein said silicide is comprised of a titanium silicide.

[c6] The method of claim 1 wherein prior to depositing said titanium layer on said interconnect structure, said interconnect structure undergoes surface cleaning.

[c7] The method of claim 1 wherein said titanium layer is deposited on said silicon substrate by a physical vapor deposition process.

[c8] The method of claim 1 wherein said titanium layer has a thickness of between about 25Å to about 250Å.

[c9] The method of claim 1 wherein said in-situ plasma nitridization process comprises converting all free titanium into titanium nitride in a hydrogen and nitrogen gas environment.

[c10] The method of claim 1 wherein said in-situ plasma nitridization process is performed at a temperature from between about room temperature to about 410°C.

[c11] The method of claim 11 wherein said in-situ plasma nitridization process is performed at a temperature from between about 325°C to about 400°C.

[c12] The method of claim 12 wherein said in-situ plasma nitridization process is performed at a temperature of about 350°C.

[c13] The method of claim 1 wherein said in-situ plasma nitridization process is performed for a period of from between about 5 to about 60 seconds.

[c14] The method of claim 13 wherein said in-situ plasma nitridization process is performed for a period of from between about 5 to about 45 seconds.

[c15] The method of claim 14 wherein said in-situ plasma nitridization process is performed for a period of about 25 seconds.

[c16] The method of claim 1 wherein said at least one titanium nitride layer is deposited on said in-situ plasma-treated titanium layer by a chemical vapor deposition process.

[c17] The method of claim 16 wherein said CVD process involves using a titanium-containing precursor selected from the group consisting of TDMAT, TDEAT and titanium tetrachloride.

[c18] The method of claim 16 wherein said CVD process involves using a nitrogen-containing precursor of ammonia.

[c19] The method of claim 1 wherein each of said at least one titanium nitride layer has a thickness of between about 15Å to about 100Å.

[c20] The method of claim 1 wherein at least two layers of titanium nitride are deposited on said in-situ plasma-treated titanium layer.

[c21] A low thermal budget MOL liner comprising a titanium-deposited layer that has been subjected to an in-situ gas plasma nitridization process.

[c22] The low thermal budget MOL liner of claim 21 wherein said liner has a thickness of between about 25Å to about 250Å.

[c23] A semiconductor device having a silicide contact, comprising
an interconnect structure having one or more contact openings which expose one or more silicide regions;
a low thermal budget MOL liner formed above said silicide contact, said liner comprising a titanium-deposited layer that has been subjected to an in-situ gas plasma nitridization process; and
one or more titanium nitride layers deposited on said low thermal budget MOL liner.

[c24] The semiconductor device of claim 23 wherein said silicide contact is comprised of silicon and a metal selected from the group consisting of cobalt, nickel, titanium, tungsten, platinum and molybdenum.

[c25] The semiconductor device of claim 24 wherein said silicide contact is comprised of a nickel silicide.

[c26] The semiconductor device of claim 24 wherein said silicide is comprised of a cobalt silicide.

[c27] The semiconductor device of claim 23 wherein said titanium-deposited layer has a thickness of between about 25Å to about 250Å.

[c28] The semiconductor device of claim 23 wherein each of said one or more titanium nitride layers has a thickness of between about 15Å to about 100Å.

[c29] The semiconductor device of claim 23 wherein said semiconductor device is subjected to a bulk tungsten filling step.

[c30] The semiconductor device of claim 29 wherein said bulk tungsten filling step is performed by a CVD process.